Status of the Organic Soils in the Scioto Marsh, Hardin County, Ohio[1]

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Abstract: Scioto Marsh in Hardin County, OH, was a 16,000-acre wetland area that was drained in the mid-1800s by channelizing the Scioto River to create farmland. The resulting soils are characterized by a thick, organic-rich A horizon that contributed to the productivity of the area. During the subsequent years, wind erosion and farming practices depleted this layer, causing the underlying B horizon to become incorporated into the till zone in many areas. This paper is a re-evaluation of the status of the A horizon, in lieu of recommendations thirty years ago on how to preserve the remaining productivity. Our study re-sampled sites from previous studies from the 1930s and 1970s. Comparisons of A-horizon thickness, organic carbon content, and bulk density indicate that the A horizon depletion has greatly diminished from its earlier pace. This is most likely due to more conservation farming practices incorporated in recent years.

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INTRODUCTION

Cultivation practices have long been known to lead to significant losses in soil organic matter, as well as increased erosion (Haas and others 1957). Tillage increases erosion through physical mixing, destruction of soil aggregates, and enhanced contact of organic matter with oxygen and microorganisms (Doran and Werner 1990). These processes can be extreme in the case of drained marshland, where soils can contain high percentages of organic carbon.

From satellite images taken over the past 26 years, the heart shape of the Scioto Marsh in Hardin County, OH, is plainly evident and apparently unchanging. This 16,000-acre remnant marsh area is currently highly productive agricultural land. The ancient (10,000 years B.P.) glacial lakebed, located in Marion, McDonald, and Roundhead townships (lat. 40° 35' N, long. 83° 40' W) lies at a low elevation of 420 m above mean sea level. Historically, the Scioto River once flowed through the area from the north, filling the marsh during times of flooding or high water levels. This resulted in a thick accumulation of reduced organic matter and peat.

The Scioto Marsh was originally a shallow glacial lake with a drift clay bed as much as 2.3 m thick. Wave action left shell marl up to 20 cm thick covering the silt and clay lake bottom. After glacial recession, a thick peat layer formed with a thickness from 0.5-3.0 m within the marsh (Siegenthaler 1977; USDA 1994). The river was not channelized at that time resulting in a slow-moving sheet flow and widespread deposition within the shallow basin. Downstream from the marsh, the river reestablished a channel and continued its southerly flow to the Ohio River. Partly based on this rich organic accumulation and potential for valuable agricultural use, as well as its reputation as a source of malaria, the marsh was drained in the mid-1850s and the Scioto River was channelized to create the productive agricultural land it remains today. Channels can be seen in Figure 1. The loose texture and high sulfur and nitrogen contents of the former marsh soils enabled the area to become the onion-growing capitol of the nation in the early 1900s, and currently is used for carrots and other root crops (Drumm 1975; Anderson 1976).

The goal of this present study is to document the changes that have occurred in soil organic carbon content and bulk density over the past one hundred years due to draining and agricultural practices.

Previous Research

In 1912, Alfred Dachnowski completed the first soil test borings in the area and published his research, "Peat Deposits of Ohio," in a Geological Survey of Ohio Bulletin. His studies indicated a once shallow lake with shell marl below the peaty surface and sand deposits surrounding the shoreline edges. At the time of his study, the peat layer covering the clay basin exceeded 3.0 m in thickness in some places. His account of the surface peat soil showed a well-decomposed soil, black and brown in color:

> "At a depth of three feet the peaty soil is grayish brown, firm, somewhat fibrous, containing seeds, fragments of rhizomes of the reed grass and of several other grasses and sedges. Below this, at a depth of five feet, the peat is greenish gray, indicating a high silt and clay content, with quantities of fibrous plant remains and shell marl."

Soil nutrient analyses by Dachnowski (1912) indicated that the peat was "of the same character and thickness" between the cultivated and uncultivated fields. Although he declined to discuss the inferences that may be drawn from this comparison, he did state that cultivation and aeration are the two main factors in the deterioration of peat, resulting in the loss of volatiles, nitrogen and sulfur. Many farmers reported that productivity had been steady for the first 30 years of cultivation, but increasingly the addition of manure was needed. Additionally, he noted that the peat soils were reverting

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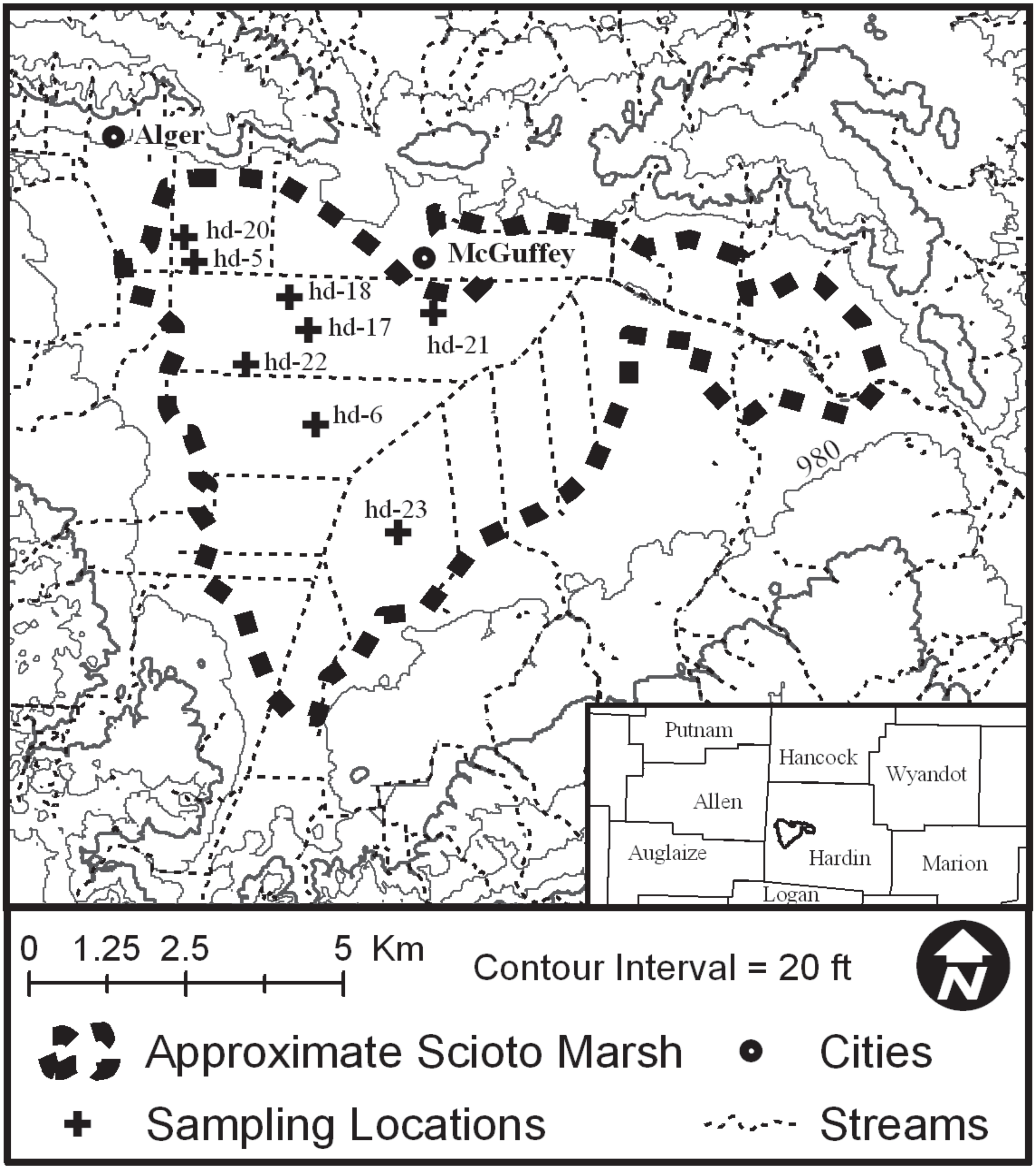

FIGURE 1. Map of Scioto Marsh, Hardin County, OH. Symbols indicate locations of samples re-analyzed for this study.

to a fine-grained material susceptible to wind erosion. The loss of moisture, which necessarily increased aeration, was also increasing the rate of organic matter decomposition. At that time, Dachnowski was advocating that plant residues be returned to the soil and not be removed as was the common practice. Indeed, by 1925 the onion growers were noticing substantially lower crop yields while farmers were tilling deeper and observing new soil textures at the surface (Anderson 1976).

The original soils of the marsh contained 20-30% organic topsoils with thicknesses averaging greater than 40 cm. Thus, they would have been classified as Histosols, had that naming system been used in 1977. Furthermore, based on descriptions of mostly decomposed, non-fibrous, mucky organic matter and the bulk densities reported by Dachnowski, the original soil classification for the freshly drained Scioto Marsh would be Typic Medisaprists. Variation of the soil surface thickness might qualify some areas as Terric Medisaprists or Limnic Medisaprists, depending on the lithology of the layer beneath the organic horizon.

A second soil survey in 1934 by G. W. Conrey and A. H. Paschall reported 'medium' organic content and thicknesses of the organic horizon reduced to 15-60 cm inches throughout the marsh area. Siegenthaler's study from 1968-1972 noted the thickness had reduced to less than 40 cm (Siegenthaler 1977). Therefore, the soils were reclassified from Histosols to what now would be called Inceptisols in the suborder Aquepts. The most recent soil survey from 1994 classifies the soils in the Roundhead-McGuffey Soil Association of level, very poorly drained soils formed in organic material and in the underlying lacustrine sediment on lake plains, subject to ponding and very slow surface runoff, near or above the seasonal high water table (USDA 1994). The McGuffey series is fine, illitic, calcareous, mesic Histic Humaquepts. The Roundhead series is fine-silty, mixed, calcareous, mesic Histic Humaquepts.

MATERIALS AND METHODS

Comparisons of organic matter content, organic horizon thickness, bulk density, and physical descriptions were made from samples obtained in 2000 with those obtained for the previous studies, including Dachnowski (1912), Conrey and Paschall (1934), Siegenthaler (1977), and the Soil and Water Conservation District (unpublished 1982). Whenever possible the same analytical technique used by the original researcher was reproduced for this study. However, the former method for organic matter content was not documented. Therefore, this study used the loss-on-ignition method, which is likely similar to what was used for the other investigations (Bartels 1996). Because all of the former studies and the Soil Survey descriptions are in feet and inches, this study also reports in feet and inches to avoid error due to converting to metric units. Statistical data are not available for the previous studies.

Identifying the location of the original sample sites was possible for six of Siegenthaler's original sites and two samples used in 1982 by the Soil and Water Conservation District. Verbal descriptions were transferred to topographic maps and converted to latitude and longitude using Maptech, Inc. software. Locations were then found using the Global Positioning System to within two meters.

Each site, denoted with the same HD prefix as used by Siegenthaler, was sampled at least five times at the corners and center of a square roughly 2.0 m on each side. Thickness of the organic layer was assessed using a soil probe. Physical description was made in the field as well as using photographs taken at the time of collection. Undisturbed samples of known volume were taken in triplicate at each of the five locations at each site for bulk density measurements. When enough organic A horizon was available the top 15 cm were compiled for organic content analyses. If less than 15 cm remained, only the organic portion was used. Results are reported as averages and standard deviations of all analyses. For consistency, the site designations used by Siegenthaler were used also for this study. Sample identification and GPS coordinates are given in Table 1. Locations are shown in Figure 1.

TABLE 1

Locations for sites in the Scioto Marsh used in this study. Site designations are those of Siegenthaler (1977).

Site	Latitude	Longitude
HD-5	40° 41' 27.19 N	83° 49' 42.34 W
HD-6	40° 40' 03.43 N	83° 48' 16.02 W
HD-17	40° 40' 53.02 N	83° 48' 23.98 W
HD-18	40° 41' 09.98 N	83° 48' 37.15 W
HD-20	40° 41' 40.25 N	83° 49' 49.24 W
HD-21	40° 41' 04.39 N	83° 46' 58.13 W
HD-22	40° 40' 33.67 N	83° 49' 04.96 W
HD-23	40° 39' 08.23 N	83° 47' 18.11 W

RESULTS AND DISCUSSION

The results for the current study are presented in Tables 2 and 3. Table 2 shows the range and average thickness of the organic-rich A horizon, percent organic carbon, and bulk density of that horizon from samples obtained in 2000. Table 3 compares the means of these data with data from the various previous studies. Current thickness of the organic-rich A horizon ranged from 4.0 in (10 cm) to 22 in (56 cm). Average thickness of all samples taken in 2000 is 9.5 in (S.D. = 3.12) (25 cm, S.D. = 5.99). Organic carbon ranged from 6.7 to 59%, while sediment taken from the remaining marshland had a current organic carbon content of 48%. Bulk densities currently range from 0.45 to 1.02 g/cm^3 for the agricultural land and 0.246 g/cm^3 for the remaining marsh.

The Scioto Marsh has been and continues to be a major, valuable agricultural region in Ohio. The presence of thick muck soils is the major contributing factor to the high productivity of the soil. However, though the loss of the top organic layer was appreciable during the time between the initial studies in the early 1900s, the loss appears to have slowed after the mid-1900s. From the eight representative sites that were sampled in 2000, the reduced thickness of these organic soils averages 8.5 in (22 cm), with a range up to 15 in (38 cm) since the 1930s. Site HD-21 shows a reversal in this trend, however the thickness was highly variable on these lake plain sediments. Some samples revealed several deep layers of

Table 2

Physical data for the Scioto Marsh soils taken in 2000.

ID*	Mean Thickness of A horizon in 2000 inches	Mean Thickness of A horizon in 2000 cm	Range in.	St. Dev. in.	(N)	Mean Organic Carbon %	St. Dev.	(N)	Mean Bulk Density g/cm³	St. Dev.	(N)	B. D.* Thickness cm* g/cm³
HD-5	9.8	24.9	8-13	1.83	5	20.97	6.24	6	1.02	0.036	6	25.40
HD-6	11.2	28.4	10-14	1.80	5	30.60	5.25	6	0.45	0.051	6	12.67
HD-17	9.2	23.4	6-13	2.56	5	30.94	4.61	6	0.52	0.039	6	12.26
HD-18	8.6	21.8	4-12	3.44	5	27.25	1.00	4	0.54	0.022	6	11.86
HD-20	7.4	18.8	4-10	2.15	5	34.59	2.38	6	0.74	0.059	6	13.89
HD-21	13.2	33.5	6-22	5.27	5	6.70	13.75	5	0.89	0.115	6	29.65
HD-22	7.4	18.8	6-9	1.36	5	32.37	7.70	6	0.72	0.023	6	13.52
HD-23	9.0	22.9	8-11	1.10	5	33.96	11.80	6	0.48	0.294	6	11.04
Marsh Sediments						47.93	9.48	4	0.25	0.024	4	

*ID designations used in this study are taken from Siegenthaler (1977).

organic material interspersed with sandy laminae, which may account for the discrepancy.

Overall, however, the loss of A-horizon thickness is greatest from 1934 to 1968, averaging close to 10 in (25 cm) during that time period. Between 1968 and 2000, the loss was never more than 4.0 in (10 cm) and generally was less than 2.0 in (5 cm).

Increased aeration associated with tilling should result in the degradation of the organic carbon through oxidation processes. The continued incorporation of the underlying mineral soil into the upper organic layer would also result in an overall lowering of the organic carbon content. However, in all samples the percent organic carbon is either higher in the 2000 samples, or similar to the previous studies. Therefore, oxidation and mineral soil incorporation do not appear to influence soil carbon content in this marshland soil. Alternately, the increased use of no-till and the incorporation of crop debris into the soil may likely result in replenishing any carbon that might have been lost to oxidation.

The reduced thickness of the organic rich soil could be due to erosion and/or the compaction of the soils by heavy machinery and cultivation practices. Bulk density determinations could help determine the influence of compaction on the organic layer thickness. The present day bulk densities are all less than 1.02 g/cm³ (mean = 0.67 g/cm³), which is low when compared with a typical mineral agricultural loamy, well-structured soil with a bulk density of 1.3 g/cm³. In the southern portion of the marsh a small portion of undisturbed marsh still remains. The bulk density of those sediments was 0.246 g/cm³, typical of marsh sediments. Bulk densities for the cultivated field soils ranged from 0.482 to 1.02 g/cm³. Site HD-17, which was reported to be neglected and unfarmed for a "fairly long period of time," had a relatively low bulk density of 0.524 g/cm³, possibly due to the lack of heavy machinery compacting the soils. Site HD-5 had the highest average bulk density of 1.02 g/cm³. This site lies in the heart of the former marsh, in the area with the greatest original A-horizon thickness. At the time of the 2000 sample collection, the soil surface was hard and difficult to penetrate with the soil probe or shovel, indicating that the loss in thickness is due partially to compaction.

Site HD-21 sits on a slight rise in the lake plain. Although the measured A horizon thickness was thicker in 2000 than any of the previous sample periods, the texture of the A horizon has always been influenced by a high mineral content and low carbon content and higher bulk density than at the other sampling locations. All studies at this location have noted the influence of mixing the underlying mineral horizons into the A horizon.

This study of the organic soils from Scioto Marsh included an exhaustive search of existing data of the marsh. Unfortunately, as is the case with so many of our valuable resources, little preexisting statistically validated data exist from which to base our conclusions on management practices. Comparing the data presented in this study with the previous studies gives compelling, but weak evidence at best, that the organic soils have been eroded or oxidized since the original studies in the early 1900s. But, it appears that the trend has slowed since the mid-1900s. The incorporation of conservation practices such as no-till or conservation tilling and the incorporation of crop residue into the soil

TABLE 3

Comparison of muck thickness from different studies. Samples are organized along a west-east transect.

	HD-20 NW Marsh Edge	HD-5 Within Marsh	HD-18 Central Marsh	HD-17 Central Marsh	HD-22 Central Marsh	HD-6 Central Marsh	HD-21 Lake Plain Rise	HD-23 Eastern Marsh
1934	8.0	22.0	22.0	24.0	18.0	18.0	8.0	18.0
1968		10.0	10.0	10.0		15.0		
1972							6.0	
1982					10.0			10.0
2000	7.0	9.8	8.6	9.2	7.4	11.2	13.2	9.0
OC								
1934								
1968			38.6	32.1		33.8	8.8	
1972	22.5	10.8						
1982					24.2			17.5
2000	34.6	21.0	27.3	30.9	32.4	30.6	6.7	34.0
BD								
1934								
1968			0.41	0.47			0.96	
1972	0.63							
1982								
2000	0.74	1.02	0.54	0.52	0.72	0.45	0.89	0.48

1934 – Conrey and Paschall 1968-1972 – Siegenthaler 1982 – Soil and Water Conservation District 2000 – Current Study

seem to be responsible for maintaining the remaining quality and quantity of the organic soils.

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LITERATURE CITED

Anderson TD. 1976. An Investigation of the Soil Resource Base of the Scioto Marsh with Respect to Relative Land Use Stability. Research report submitted to the Faculty Research Committee, Bowling Green State University FRC Grant #210049.

Bartels JM. 1996. Part 3: Chemical Methods in Soil Analysis. Soil Science Society of American Book Series No. 5. Madison (WI): American Society of Agronomy. p 1001-5.

Conrey GW, Paschall AH. 1934. A Key to the Soils of Ohio. Special Circular No. 44. Wooster (OH): Ohio Agricultural Experiment Station.

Dachnowski A. 1912. Peat Deposits of Ohio: Their Origin, Formation and Uses. Fourth Series, Bull 16, Geological Survey of Ohio, Columbus, OH. Springfield (OH): Springfield Publishing Co.

Doran JW, Werner MR. 1990. Management and soil biology. In: Francis CA, Flora CB, King ID, editors. Sustainable Agriculture in Temperate Zones. New York: John Wiley. p 205-30.

Drumm C. 1975. A Complete History of the Scioto Marsh. Kenton (OH): Hardin County Historical Society.

Haas HJ, Evans CE, Miles ER. 1957. Nitrogen and Carbon Changes in Soils as Influenced by Cropping and Soil Treatments. USDA Technical Bulletin 1164. Washington (DC): US Government Printing Office.

Siegenthaler VL. 1977. The Changing Muck Soils of the Scioto Marsh. Sidney (OH): US Dept of Agriculture, Soil Conservation Service.

[USDA] United States Department of Agriculture. 1994. Soil Survey of Hardin County, Ohio. Kenton (OH): Soil Conservation Service.